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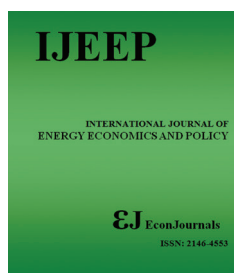
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Decommissioning Planning of Offshore Oil and Gas Fields in Vietnam: What Can be Learnt from Mine Closure Planning in Scotland?

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ABSTRACT

Due to the lack of necessary requirements in the existing regulations for decommissioning of offshore oil and gas fields in Vietnam, this paper makes policy recommendations based on the comparison between the decommissioning planning of offshore oil and gas fields in Vietnam and the similar closure planning of opencast coal mines in Scotland. The comparative analysis shows that there is interplay between the project context and restoration/decommissioning outcomes in the cases of three opencast coal mines in East Ayrshire, Scotland and X oil field in Vietnam. The influencing contextual factors in both cases can be categorized as biophysical and material conditions, community attributes, biodiversity's interest, socioeconomic context and rules. Based on such analysis, additional issues should be considered while preparing future decommissioning plans and updating relevant laws in Vietnam. Particular challenges include compliance monitoring, shell mounds, drill cuttings, financial assurance, consultation with local communities and recognition of their interests, rigs-to-reefs, coastal communities' socioeconomic development, and investment in research, training and education about oil and gas decommissioning.

Keywords: Offshore Platforms, Opencast Coal Mines, Decommissioning Planning, Closure Planning, Decommissioning Outcomes, Restoration Outcomes

JEL Classifications: L52, O21, O25

1. INTRODUCTION

The outstanding potential of Vietnam's ocean economy is oil and gas resources, with the estimated reserves of about 3.0-4.5 billion m³ oil equivalent, of which 30-35 percent has been discovered (Ha, 2018). There are hundreds of exploration and production oil and gas wells in Vietnam's sea (Ha, 2018); however, as in other regions, many of these production projects are reaching an end soon as oil reserves become exhausted (Burdon et al., 2018; Viet Nam News, 2019). As a result, decommissioning will be a focused activity of the Vietnam oil industry in the coming years, with X oil field expected to be the first for decommissioning in 2020 (POC1, 2019; POC2, 2020).

The life cycle of a mine consists of eight phases: design, exploration, permitting, construction, operations, decommissioning/closure, post-closure and relinquishment (World Bank Multistakeholder Initiative, 2010). Similarly, six phases are in the cycle of an oil and gas project: lease, exploration, development, production, closure and post-closure (Tordo, 2007). There have been cases of mines and oil and gas fields being abandoned without specific plans or clarification of liable parties for closure and decommissioning funding, and this has led to negative perceptions of these industries (World Bank Multistakeholder Initiative, 2010). In many nations, the legacy of unplanned closures and unrestored land has become a burden on the governments (World Bank and International Finance Corporation, 2002).

Since dealing with closure/decommissioning¹ challenges at the outset of the project is the most efficient way, governments all over the world are becoming aware of the importance of perceiving and proactively managing matters relating to closure and decommissioning as soon as practicable (World Bank Multistakeholder Initiative, 2010). A closure plan or restoration² plan is currently required to be an integral part of mining proposals in most countries (Tordoff et al., 2000; Sassoon, 2009). With regards to oil and gas decommissioning, the Australian Government encourages operators to undertake decommissioning planning at the early phases of the project as part of the field development plan (Department of Industry, Innovation and Science, 2018).

In Vietnam, oil and gas decommissioning is specified in detail in Decision 40/2007/QĐ-TTg from 2007 to 2018 and Decision 49/2017/QĐ-TTg since 12 February 2018. Apart from such legislation, decommissioning plans set out decommissioning options and methodology, cost estimation, and health, safety and environmental management, etc. for decommissioning of each field (PVEP POC, 2015). As no offshore oil and gas fields in Vietnam have been decommissioned yet, the aims of this paper are to examine:

- How the existing decommissioning legislation in Vietnam and decommissioning plans for offshore oil and gas fields influence decommissioning outcomes and in what particular aspects?
- Conversely, what and who can be potentially impacted by decommissioning outcomes and how?
- What should be considered during decommissioning planning of offshore oil and gas fields in Vietnam in order to improve decommissioning outcomes?

Given our understanding of mine restoration, the authors hypothesize that the project context which includes the situation of marine environment after the field production, decommissioning cost, financial assurance, coastal communities' interest, biodiversity's interest, socioeconomic context and rules can influence decommissioning options and hence decommissioning outcomes. Conversely, decommissioning outcomes can also make impacts on similar project contextual factors, namely marine environment, coastal communities' interest, biodiversity's interest and socioeconomic development.

2. LITERATURE REVIEW

Addressing the gap in the literature, Le (2018) explored the influence of the context of a mining project on restoration outcomes

¹ In this paper, 'decommissioning' is defined as 'the process by which options for the physical removal, disposal (or modification...) of structures at the end of their working life are assessed, dismantled and removed' and 'closure' is understood as 'the period after the end of commercial resource extraction' when 'decommissioning and rehabilitation activities are conducted' (World Bank Multistakeholder Initiative, 2010, p. GG-2). The research focuses on closure in the mining industry and decommissioning in the oil and gas industry.

² The authors pay attention to post-mining restoration. While recognising different terms used to refer to activities to repair mined and other degraded lands such as *remediation*, *rehabilitation*, *restoration* and *reclamation* (Finger et al., 2007; The Australian Government, 2016), the authors use the term 'restoration' to replace the associated terms in the original documents to refer to the activities that repair mined land and are implemented after the cessation of operations in a mining project.

and the stakeholders' interactions during closure planning³ with the cases being opencast coal mines in East Ayrshire, Scotland. However, this has not been investigated in terms of the oil and gas industry, that is, how the context of an oil and gas project influences decommissioning outcomes and the stakeholders' interactions during decommissioning planning. Due to the limited material available, this research does not analyse in detail the stakeholders' interactions during decommissioning planning but focuses on analysing the interface between an oil and gas field's context and decommissioning outcomes, using X oil field in Vietnam as the case for investigation.

The influence of the oil and gas project context on decommissioning outcomes was explored by Bernstein et al. (2010) who examined how the selection of decommissioning options for offshore oil and gas platforms in southern California was influenced by legal and regulatory contexts. Their analysis provides decision makers and interested parties with knowledge of the alternative choices available in order to choose a suitable one. In a similar manner, this research analyses how the preparation of decommissioning options for X oil field was influenced by contextual factors, including legal and regulatory ones. However, since the decommissioning options for X field were already prepared and the tentative choice among the options was already made, this research does not have the same aim as Bernstein et al.'s (2010) study. Rather, we look to develop recommendations covering additional issues to be considered in developing decommissioning plans for future oil and gas fields in Vietnam. The literature review shows that this has not been done so far. Regarding the influence of decommissioning outcomes on the project context, the authors pay attention to Ekins et al.'s (2005; 2006) study which assesses non-financial decommissioning outcomes of different decommissioning scenarios for offshore oil and gas platforms in the North Sea and the work of Bernstein et al. (2010) and Pondella et al. (2015) which analyse the potential impacts of decommissioning options for offshore oil and gas platforms in southern California.

In order to provide recommendations for offshore decommissioning planning in Vietnam, the researchers compare the interplay between the project context and decommissioning outcomes in X oil field to that in three opencast coal mines in East Ayrshire, Scotland. Where the former is unclear, it is predicted based on global decommissioning practices. Similar research has not been done in Vietnam, though in the international context McCauley (2018) makes a comparative analysis of motivational frames of decommissioning in the Scottish oil and gas industry and the German nuclear industry. A comparison of the closure process between the mining industry and the oil and gas industry has also been made by Snashall (2018) in terms of social and economic impacts.

3. METHODOLOGY

3.1. Conceptual Framework

Aiming to support the comparative analysis of the interplay between the project context and restoration/decommissioning

³ Given the association of restoration with mine closure, the term 'closure planning' is used to refer to the activity/process in the mining industry.

outcomes, the study has developed a conceptual framework adapted from the Institutional Analysis and Development (IAD) framework (Ostrom, 2005; 2007). The IAD framework was applied by Orji (2018) to stakeholder analysis in environmental management in the Nigerian oil-producing region and by Le (2018) for analysing the influence of the project context on restoration outcomes. In this article, the IAD framework will be employed again to guide the comparative analysis, with minor amendments of Le's (2018) framework as shown in Figure 1 below.

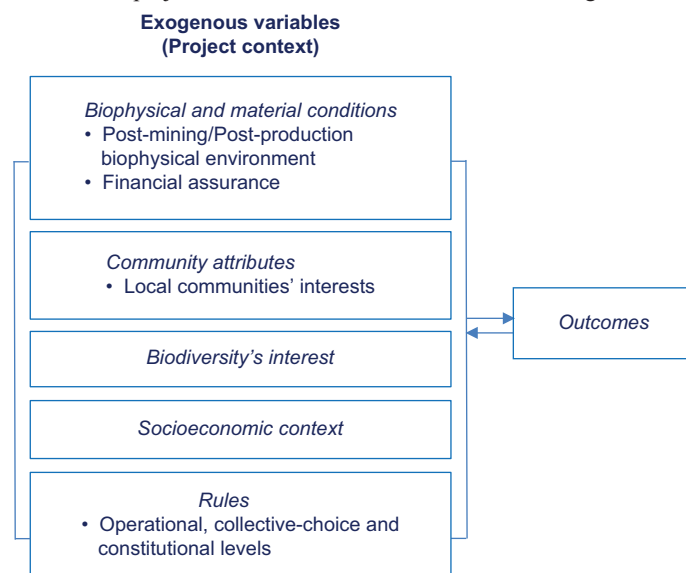
The following will explain the interplay between each project contextual factor (exogenous variable) and restoration/decommissioning outcomes in mining and petroleum industries. Such interplay will then be analysed in the context of Scottish coal mines and X oil field in Section 5.

3.2. Project Context

3.2.1. Biophysical and material conditions

Mine restoration and offshore decommissioning are both impacted by the biophysical conditions of the sites. In the mining context, the establishment of restoration goals is greatly influenced by the post-mining environment, given the disturbance caused by mining during operations (The Australian Government, 2016). True restoration of highly disturbed native ecosystems is a challenging task worldwide (Gillespie et al., 2015) and is impossible in many sites (Gardner and Bell, 2007). Similarly, in the oil and gas context, the situation of the marine environment around an offshore platform after the production phase may affect decommissioning options. There are many decommissioning options such as complete removal of installations which is the default in the North Sea, "rigs-to-reefs" and other alternatives in the Gulf of Mexico, Southeast Asia and Australia, etc. (Sommer et al., 2019). Given their nature, restoration/decommissioning options will have certain impacts on the site environment.

Figure 1: The adapted IAD framework that reflects the interplay between the project context and restoration/decommissioning outcomes



Source: The authors (adapted from Ostrom, 2005; 2007 and Le, 2018)

Mine restoration and offshore decommissioning are also impacted by material conditions which include financial assurance. Restoration and decommissioning are both expensive tasks and theoretically occur at the end of the productive life of a mine or an oil field when revenue does not exceed operation and maintenance costs (Ferreira and Suslick, 2000; Peck and Sinding, 2009). Financial assurance is the available amount of money to the government for restoring or decommissioning the site when the operator goes into liquidation, leading to premature closure or decommissioning, or when the operator carries out the work incompletely or improperly (Ferreira and Suslick, 2000; Peck and Sinding, 2009). It is seen as the most efficient "insurance" mechanism to assure the necessary funding for undertaking restoration and decommissioning work properly (World Bank Multistakeholder Initiative, 2010).

3.2.1. Community attributes

One of the community attributes in the original IAD framework is community interests (Ostrom, 2005a). Due to the proximity of mine sites, mine restoration can make direct impacts on local communities' living environment and their livelihoods. In addition, given their understanding of the natural environment as well as the history and socioeconomic context of the surrounding area, local communities may provide valuable ideas for restoration design. Therefore, integrating community interests into restoration design is important for the success of a restoration plan (Cherry, 2008, cited in Kuter, 2014, p. 842). Similarly, offshore oil and gas activities can make positive and negative effects on nearby coastal communities' tourism (Jefferies, 2018), fishing and access to marine resources (Snashall, 2018), thus those communities may provide insightful comments on decommissioning options with their knowledge of the marine environment around the oil fields. Then conversely, if local communities' opinions are taken into account while preparing a restoration/decommissioning plan, restoration/decommissioning outcomes can be more satisfactory to local communities' interest.

3.2.2. Biodiversity's interest

The global extent of mining impacts on biodiversity is smaller than other industries such as agriculture, aquaculture and logging (Baillie et al., 2010); however, the magnitude of the impacts can be locally significant (Salomons, 1995). Restoration provides the opportunities for rectifying such impacts (ICMM, 2006). In the oil and gas context, oil platforms can be habitats not only for settlement but also for growth of reef fishes (Pondella et al., 2015). Studies have shown that fish larvae are not only attracted to but also grow at artificial structures, leading to fish production enhancement (Pondella et al., 2015). Therefore, a suitable decommissioning option for an oil platform can be beneficial for marine biodiversity. Given that biodiversity is voiceless (Wood et al., 2000), the researchers consider biodiversity as an unvoiced 'stakeholder' that has its own interest and explores to what extent its interest is taken into account by observed stakeholders in closure/decommissioning planning. Biodiversity's interest is a new exogenous variable in compared to the original IAD framework.

3.2.3. Socioeconomic context

Mine restoration with different objectives, for example, creating new landform, land capability or final land use (The Australian Government, 2016), can help maintain or even improve the socioeconomic development of local communities. This is particularly important for some local communities, for instance, residential mining communities which are set up to provide workforce for mining projects, whose socioeconomic development used to greatly depend on mine extraction (Browne et al., 2011). Similarly, offshore field decommissioning can lead to economic improvement in the coastal areas due to its employment and socioeconomic effects (Snashall, 2018). It can also contribute to the socioeconomic development of onshore communities due to direct investment in developing new skills to prepare for decommissioning work (McCauley, 2018). Therefore, local communities' socioeconomic context should be considered in closure/decommissioning planning. It should be noted that socioeconomic context is also a new exogenous variable in compared to the original IAD framework.

3.2.4. Rules

There are same rules associated with closure and decommissioning planning processes at different levels. Restoration plans should specify the restoration outcomes that are achievable and sustainable through the enforcement of minimum performance standards (Powell, 1988, cited in Kuter, 2014. p. 839). Similarly, decommissioning plans normally provide details for decommissioning work through examination and assessment of decommissioning alternatives (Osmundsen and Tveterås, 2003; DMIRS, 2017). Then restoration/decommissioning plans can directly influence operators' restoration/decommissioning work on site and thus can be considered as operational rules (Polski and Ostrom, 1999; Ostrom, 2007). Since planning permission for mine extraction defines the decision with restoration conditions on the planning application (EAC, 2011b) and national laws often provide the legal framework for decommissioning plans (DMIRS, 2017), they can be considered as collective-choice rules that are used to change operational rules (Ostrom, 2007). National mining laws and regulations inform the decision making of mine restoration (Kuter, 2014). Whilst, decommissioning practices, despite being substantially decided by national governments, are influenced by international regulations (Osmundsen and Tveterås, 2003). For example, Article 5(5) of the Convention on the Continental Shelf, 1958 requires abandoned or disused installations to be fully removed (Convention on the Continental Shelf, 1958). OSPAR Decision 98/3 also prohibits "the dumping, and the leaving wholly or partly in place, of disused offshore installations within the maritime area" (OSPAR Commission, 1998. p. 16). These Conventions inform the related national regulations of the nations ratifying them (United Nations Treaty Collection, n.d.; EUR-Lex n.d.) or can directly influence a government's decision on decommissioning plans (Osmundsen and Tveterås, 2003). Therefore, these Conventions and national mining laws and regulations can be seen as constitutional rules that are used to change collective-choice rules (Polski and Ostrom, 1999; Ostrom, 2007).

3.2.5. Outcomes

In the original IAD framework, 'outcomes' refer to the results of actors' interactions (Ostrom, 2007). The term can be understood as restoration outcomes which are the results of restoration work in the mining industry or as decommissioning outcomes which are the results of decommissioning work in the oil and gas industry and can be seen through decommissioning options in a decommissioning plan if decommissioning work has not been undertaken yet.

4. MATERIALS AND METHODS

Case study method is used for this research since it is appropriate for answering a "how" question (Yin, 2014).

Regarding offshore oil and gas fields in Vietnam, the authors chose X oil field as the case. Although it is impossible to say that X field represents all the offshore oil and gas fields in Vietnam due to their unique characteristics, the decommissioning planning process of all the fields is generally the same (POC1, 2019). In addition, X field was expected to be decommissioned in 2020 and thus would be the first field to be decommissioned in Vietnam (POC1, 2019; POC2, 2020) and its field decommissioning plan can be said to be the typical example for other fields' decommissioning plans (POC2, 2019a).

Meanwhile, the authors chose three opencast coal sites in East Ayrshire as the Scottish mining cases. Such sites are Dunstonhill Surface Mine (Dunstonhill), Duncanziemere Surface Mine (Duncanziemere) and Netherton Surface Mine (Netherton) which are the cases in Le's (2018) study. In this research, those mines were also chosen for comparing with X oil field because of the literal replication⁴ and theoretical replication among them (Appendix 1).

The research triangulated data from four sources: documentation, semi-structured interviews, informal conversations and telephone conversations. The data about X oil field were collected from February to April 2019. The main source of data during this period was documentation. In addition, one semi-structured interview and one informal conversation followed by several telephone conversations were undertaken with PetroVietnam Domestic Exploration Production Operating Company Limited (PVEP POC). Whilst, the data related to three opencast coal mines in East Ayrshire, Scotland were collected during the corresponding author's PhD study, particularly between March 2016 and April 2018. The main sources of data during this period were documentation and semi-structured interviews. Regarding semi-structured interviews, apart from 29 face-to-face interviews, three interviews were conducted electronically via email and LinkedIn in the form of self-administered semi-structured questionnaires.

4 Literal replication means the cases have similar characteristics that predict similar results and theoretical replication means the cases have different characteristics that predict contrasting results but for anticipatable rationales (Yin, 2014).

5. OVERVIEW OF X OIL FIELD, VIETNAM AND THREE OPENCAST COAL MINES IN EAST AYRSHIRE, SCOTLAND

5.1. X oil field, Vietnam

X oil field is situated in Block Y, about 205 kilometres to the southwest of Ca Mau Cape (Trung tâm nghiên cứu và phát triển an toàn và môi trường dầu khí, 2017). The field was developed since 24 November 2008 (PVEP, 2015; POC2, 2020).

Four alternatives were considered for decommissioning X oil field in the field decommissioning plan. Alternative 1 refers to the retainment of the wellhead platform for further development of Block Y; however, this was considered to be unfeasible (PVEP POC, 2015). By virtue of its location, the wellhead platform will be modified to a platform under the management of the Vietnam People's Navy/Ministry of Defence under Alternative 2. Nevertheless, this alternative was not further developed because the Vietnam People's Navy/Ministry of Defence would not receive the handover of the wellhead platform after consideration of the operation and maintenance cost, manpower and particularly the 2002 Declaration on the Conduct of Parties in the South China Sea⁵ (PVEP POC, 2015). Following Alternative 3, the wellhead platform's jacket will be disposed whereas the topside will be retained in its entirety, transported to the shore and possibly altered for other projects. Although this approach is technically feasible, the probability of reusing the entire topside for other projects was low and offshore decommissioning work would be more expensive due to the high cost of hiring Heavy Lift Vessels (PVEP POC, 2015). Similarly, Alternative 4 is about complete removal of the wellhead platform but its jacket and topside will possibly be cut into sections and transported to the shore to be disposed. Due to being technically feasible and given possibly simplest and flexible offshore decommissioning work, higher probability of cost optimisation from utilising smaller lifting and transportation means, and compliance with national legal requirements, this approach will be suggested as a basis for more research and implementation (PVEP POC, 2015).

5.2. Three Opencast Coal Mines In East Ayrshire, Scotland

The liquidation of the two main operators in Scotland – ATH Resources plc in December 2012 and Scottish Resources Group Limited in April 2013 (and their subsidiaries Aardvark TMC Limited (Aardvark) in May 2013 and Scottish Coal Company Limited (Scottish Coal) in April 2013 respectively) led to 32 mines left abandoned across central Scotland with the estimated funding shortfall of £200 million for restoring the sites (EAC, 2013; Friends of the Earth Scotland and RSPB Scotland, 2013; The Sunday Herald, 2013; RSPB Scotland, 2014). The liquidation made the greatest impact on East Ayrshire with 22 mines left abandoned and the estimated funding shortfall of about £132 million (The Sunday Herald, 2013; RSPB Scotland, 2014). Dunstonhill, Duncanziemere and Netherton were among those mines and had restoration and

aftercare bonds to ensure the performance of restoration and aftercare obligations in case of the operators' default (EAC, 2013; 2015a; 2015b) but even if such bonds were fully secured, they would not be sufficient for restoring the mines to the original restoration plans (EAC, 2013). The situation was even worse because the restoration bond for Duncanziemere could not be secured whilst those for Dunstonhill and Netherton were secured with the reduced values (EAC 2015c; 2017). Thus, the sites had to be restored to the revised restoration plans which are of lower standards than the original ones (EAC 2014; 2015a; 2015b).

6. RESULTS

6.1. Interplay Between Biophysical and Material Conditions and Restoration/Decommissioning Outcomes

6.1.1. Biophysical conditions

Regarding Scottish coal mines, the site restoration was constrained by the biophysical conditions of the sites at the time of the operators' liquidation, especially large water filled voids and large overburdens (EAC, 2014; 2015a; 2015b). Given the limited funding and these major biophysical constraints, large water filled voids and large overburdens which should have been removed to fill the voids remained, especially the overburdens in Duncanziemere still contained exposed rock faces following the revised restoration plans (EAC, 2014; 2015a; 2015b). These biophysical constraints imply the importance of compliance monitoring with the appointment of the Independent Mining Engineer in enforcing the operator to comply with the rules, given the requirement of progressive restoration in the planning permission for the sites (EAC, 2006; 2010a; 2011b).

In contrast, the biophysical environment of X oil field was not seen as the constraint for the field decommissioning that led to the preparation of decommissioning options (PVEP POC, 2015). Due to the great remoteness of the development area which is 205 kilometres offshore south of Ca Mau Cape, most of the development's activities would only affect the offshore environment around the development area. Therefore, components of such environment including the seawater, the seabed sediment and marine organisms would be mainly impacted during the project process (TSJOC, 2007). According to the Environmental Impact Assessment (EIA) report, during the drilling phase⁶, there would be minor effects of the local alterations of benthic community induced by drilling pollutants at the discharge site on the ecosystems in the South Vietnam Sea due to the small scale of the real affected area and its high energy oceanographic features (TSJOC, 2007). During the production phase, the impacts of produced water discharge, drainage water and treated domestic sewage on the marine environment would also be minor or negligible (TSJOC, 2007). These could be proved through two environmental monitoring surveys undertaken in January 2016 and August 2018 in order to prepare for the decommissioning of X field. The microbenthic community in the development area was recorded to be moderately diverse and abundant in the former and to be diverse and balanced in the latter (PVEP POC, 2016; 2018). Both surveys also showed

5 2002 Declaration on the Conduct of Parties in the South China Sea. <https://cil.nus.edu.sg/wp-content/uploads/2017/07/2002-Declaration-on-the-Conduct-of-Parties-in-the-South-China-Sea.pdf> (accessed 15 March 2019).

6 Drilling phase belongs to development phase (Tordo, 2007).

that all chemical and biological parameters of marine water quality and sediment quality complied with the relevant national technical standards (PVEP POC, 2016; 2018). Then compliance monitoring was not an issue in this case to ensure the operator to comply with the relevant environmental regulations.

Large water fill voids left in the Scottish coal sites, especially those on the Duncanziemere and Netherton sites having some ungraded sides with steep slopes (EAC, 2014; 2015a; 2015b) could raise safety issues such as flooding, people falling or jumping into the voids and drowning, etc. (Le, 2018). Regarding offshore decommissioning, a safety aspect that should be handled is shell mounds which are a mixture of drilling mud and shell debris of species forming over time under offshore structures (Henrion et al., 2015). Since drilling mud is gradually cleaner, shell mounds are effectually covered by cleaner and newer sediments; therefore, dredging to remove shell mounds which only occurs in complete platform removal will create deeper and more polluted layers and possibly disperse pollutants in a wider extent in the short time. Meanwhile, non-removal of shell mounds may lead to the scattering of pollutants in the long time (Henrion et al., 2015). Capping shell mounds can be an alternative to removing shell mounds to isolate pollutants but may result in obstructions on the seabed (Bernstein et al., 2010), thus may not be accepted following Vietnam's legislation due to inducing navigation hazards (Quyết định 49/2017/QĐ-TTg năm 2017).

Also relating to drilling mud, drill cuttings are the primary source of pollution during the production phase and comprise drilling mud, speciality chemicals and fragments drilled from the borehole (Lakhal et al., 2009). Drill cuttings usually contain hydrocarbons and traces of heavy metals, PCBs and NORM (Naturally Occurring Radioactive Material) from the formation (Ekins et al., 2006). Similar to shell mounds, the fate of cuttings piles is not mentioned in the decommissioning plan for X field as well as Vietnamese laws (Quyết định 40/2007/QĐ-TTg năm 2007; PVEP POC, 2015; Quyết định 49/2017/QĐ-TTg năm 2017). Drill cuttings can be dredged with either onshore or offshore processing; otherwise, they can be left in situ (Ekins et al., 2006). Regarding the latter, drill cuttings piles can be covered with a sand layer followed by a gravel filter layer and an outer protective layer of armour stone to hamper leaching of hazardous substances to the surrounding environment. This is considered to be a low-risk approach which does not affect marine ecosystems negatively (Ekins et al., 2006). Since drill cuttings piles vary from site to site (Lakhal et al., 2009), if leaving them uncovered, they would make different impacts on different sites. In cases where drill cutting piles include many potentially hazardous chemicals, they can become extremely toxic due to synergistic effects of various contaminants (Lakhal et al., 2009).

6.1.2. Material conditions

Financial assurance for oil and gas decommissioning in Vietnam is in the form of financial guarantee fund which is paid annually by the operator during the project life under both the relevant regulations (Quyết định 40/2007/QĐ-TTg năm 2007; Quyết định 49/2017/QĐ-TTg năm 2017). Particularly, annual payments to the financial guarantee fund were/are calculated according to the following formulas:

$$\text{Payment level} = \frac{\begin{array}{l} \text{The production within the year} \\ \times (\text{Total decommissioning cost} \\ - \text{The paid balance}) \end{array}}{\text{Remaining recoverable reserves}} \quad (1)$$

(Quyết định 40/2007/QĐ-TTg năm 2007)

Or

$$E_n = \frac{A_n \times (B_n - C_{(n-1)} - I_{(n-1)})}{D_n} \quad (2)$$

in which:

- E_n : The level of payment in year n, the calculation unit is USD
- A_n : The production in year n, defined by the actual production in the respective year, the calculation unit is the barrel of oil equivalent
- B_n : The total decommissioning cost updated in year n, $B_n = (b_1 - b_2)$, in which:
 - + b_1 : The total decommissioning cost estimated in the decommissioning plan (most recently approved), the calculation unit is USD
 - + b_2 : The cost estimate defined in the decommissioning plan (most recently approved) corresponding to the equipment, property or structure decommissioned up to year (n-1), the calculation unit is USD.
- $C_{(n-1)}$: The balance of the financial guarantee fund on December 31st of the year (n-1), defined by the total balance of all the bank accounts to which PetroVietnam (PVN) send the financial guarantee fund of the respective field, and certified in writing by the relevant commercial banks, the calculation unit is USD.
- $I_{(n-1)}$: The profit from the savings accounts received by organisations and individuals after PVN, on behalf of them, fulfill all the duties with the national budget (if any) for the year (n-1).
- D_n : The remaining recoverable reserves, $D_n = d_1 - d_2$, in which:
 - + d_1 : The recoverable reserves defined in the economic development plan or the early production plan already approved by authorities up to the end of the year n, the calculation unit is the barrel of oil equivalent.
 - + d_2 : The total production accumulated from the relevant field(s) up to the year (n-1), the calculation unit is the barrel of oil equivalent.

(Quyết định 49/2017/QĐ-TTg năm 2017)

The methodologies used to calculate the amounts mean that what the operator pays to the financial guarantee fund during the project life is just part of the decommissioning cost and thus would not ensure the total decommissioning cost of the field is fully covered if premature closure occur in cases of economic downturn or where the operator goes into liquidation.

Meanwhile, the financial assurance for the Scottish coal sites prior to the operators' liquidation was in the form of surety bonds (EAC,

2010b; 2010c; 2011a) which are similar to insurance policies in that annual premiums are paid by the operator to maintain the bond (Ferreira and Suslick, 2000). This form of financial assurance is more advantageous than the financial guarantee fund under Vietnam's law because if the operator is bankrupt at some point of the project life, the government will be paid by the surety company for full restoration/decommissioning work providing that surety bonds are precisely calculated and strictly monitored. However, in the cases of Scottish coal sites, the local government – East Ayrshire Council failed to do so at the planning stage and during the operations phase (Mackinnon et al., 2014). Thus, at the time of the operators' liquidation, there were wide gaps between the bond value as granted and the cost for restoring the sites to the originally approved restoration plans (EAC, 2013).

The liquidation of operators has never happened to the oil and gas industry in Vietnam and apart from laws, there would be terms in petroleum contracts that bind operators' liabilities (POC2, 2019b). Regarding laws, according to Article 20 of Decision 40/2007/QĐ-TTg, within one year prior to the completion of the petroleum contract or the expiry of the petroleum production period as specified in the field development plan, organisations or individuals must recalculate the financial guarantee fund on the basis of recalculating the total decommissioning cost, the production within the petroleum contract and the recoverable reserves at this time (Quyết định 40/2007/QĐ-TTg năm 2007). In the case of X field, before handing over the field in 2013, due to the early cessation of the Production Sharing Contract, TSJOC had to reevaluate the financial guarantee fund and add to the fund to make it sufficient for decommissioning the field following this article (POC2, 2019b). This means the previous operator of X field had complied with the legal requirements of the financial guarantee fund before leaving the project. However, given what has occurred elsewhere, no one can assure a similar situation will never occur in Vietnam.

6.2. Interplay Between Community Attributes and Restoration/Decommissioning Outcomes

As indicated in the EIA report for X field, a detailed field decommissioning plan was not prepared at the time of EIA due to changes of environmental regulations and communities' opinions about field decommissioning over time (TSJOC, 2007). There would be discussions among parties about the field decommissioning plan and decommissioning options based on the recommendations and approval of relevant authorities (TSJOC, 2007). In this regard, according to World Bank Multistakeholder Initiative (2010), before the cessation of the production, a complete decommissioning plan should be prepared, consulted and reviewed with authorities, local communities and other related parties. It is not indicated in the field decommissioning plan for X field that local communities' interests had been consulted; however, this is not compulsory following Decision 40/2007/QĐ-TTg or Decision 49/2017/QĐ-TTg (Quyết định 40/2007/QĐ-TTg năm 2007; Quyết định 49/2017/QĐ-TTg năm 2017). Consulting local communities during the preparation and development of a field decommissioning plan not only ensures decommissioning outcomes are more satisfactory to local communities' interests and thus ensures equality and avoids any possible conflicts (Fowler et al., 2014)

but also helps improve the quality of decommissioning outcomes since they are familiar with the marine environment around the oil field. These could be proved through the restoration of opencast coal mines in East Ayrshire, Scotland. For example, consulting with Skares community made East Ayrshire Council change their draft restoration plan so that no "water body of any scale" would be left following the restoration of the Skares void, which would address the local community's health and safety concerns and hence receive their support (EAC, 2016b). Or in the Dunstonhill case, the Cunninghame Ramblers advised the local government that the tops of the overburdens should be seeded and grassed since it would create a more welcoming environment for ramblers at the end of the journey (EAC, 2016a), which would help enhance the local tourism prospects.

6.3. Interplay Between Biodiversity and Restoration/Decommissioning Outcomes

Regarding Duncanziemere, Dunstonhill and Netherton, the biodiversity value of critical sites around the project areas continued to be of interest to the stakeholders involved during the restoration process after the previous operators' liquidation, especially Scottish Natural Heritage (SNH) (Le, 2018), a statutory agency for natural heritage in Scotland⁷ (The National Trust for Scotland and Scottish Natural Heritage, 2008). For example, considering the Low Moss raised bog as the most significant biodiversity resource adjacent to Duncanziemere, SNH pushed for restoration funds to be allocated for backfilling works beside the bog so that it is permanently supported, which means less funds would be available for other works, given the constrained restoration funds (Le, 2018).

As previously mentioned, offshore platforms can be beneficial for fish production enhancement and hence marine biodiversity which, however, is not indicated in the preparation of decommissioning options for X oil field. According to relevant studies, there are certain effects of complete removal of offshore platforms on marine resources. Since offshore platforms are shown to function as refuges and habitats for marine species, such efficacy will stop following complete removal as offshore installations are removed and fishing prohibition in the safety zone is ended (Ekins et al., 2006). Comparing the benefits for biodiversity and those for local communities, the decrease of biological production possibility of particular valuable species as a result of complete removal can exceed the likely increase in fishable area (Kruse et al., 2015). This is probably true for X field since the coastal communities' fishery may not improve substantially following complete removal of the platform as indicated later. Given this fact, while "rigs-to-reefs" following which oil platforms are retained as artificial reefs (Fowler et al., 2014) has not been considered for X field, this can be a decommissioning option for other future oil fields in Vietnam. Then 'rigs-to-reefs' should be clearly introduced as one of the rationales for retaining offshore platforms in Vietnam's future regulations as it has not been done so in the relevant regulation⁸ (Quyết định 40/2007/QĐ-TTg năm 2007; Quyết định 49/2017/

7 Since SNH is a Scottish statutory agency, their requirements can be considered as constitutional rules following the definition of constitutional rules in Section 3.

8 In Decision 49/2017/QĐ-TTg (Article 23, Item 1(g)), 'rigs-to-reefs' can be understood as offshore structures that prove to be beneficial when being retained (Quyết định 49/2017/QĐ-TTg năm 2017).

QD-TTg năm 2017). Because offshore installations usually offer settlement for large amounts of exploited fish species, they can become aggregation devices if fishing is encouraged around them (Schroeder and Love, 2004). Therefore, for the benefit of marine biodiversity as well as the concern of fishing hazards, if rigs-to-reefs is chosen for decommissioning deep-sea fields like X field, clearly-notified exclusion zones that prohibit fishing must be set up surrounding the offshore installations (Macreadie et al., 2011). In addition, evaluation of potential pollution risks and ultimate liabilities of maintaining the offshore installations should be undertaken (DMIRS, 2017).

Some particular approaches of rigs-to-reefs are leaving the rig in situ, toppling the whole installation in its existing location, partially removing the rig in its existing location, and moving the rig to a different location (Macreadie et al., 2011). These approaches imply that offshore installations are left on the seabed, which may impede marine transportation and lead to navigation hazards (Techera and Chandler, 2015). This issue has been addressed by many international laws. Apart from the Convention on the Continental Shelf, 1958 and OSPAR Decision 98/3 mentioned earlier, the United Nations Convention on the Law of the Sea, 1982 (UNCLOS) in its Article 60(3) specifically indicates that disused installations or structures must be removed to ensure “safety of navigation” and those whose depth, position and dimensions are partially removed must be made public suitably (United Nations Convention on the Law of the Sea, 1982). This is also reflected in Vietnamese law, particularly, Decision 49/2017/QĐ-TTg requires that all the piles, pipes and structures installed down to the seabed must be cut naturally under the seabed to ensure no emergence of any parts and no interference with navigation and other marine activities (Quyết định 49/2017/QĐ-TTg năm 2017). Therefore, navigation hazards should be considered if rigs-to-reefs is chosen for decommissioning other oil fields in Vietnam.

Nevertheless, complete removal can also bring ecosystem value in terms of creating a marine zone which is essential for recruiting particular species and offering crucial chances for larvae to settle prior to being swept out to sea and dying (Kruse et al., 2015). In addition, it can contribute to restoring soft bottom habitats, especially in cases of removing shell mounds (NOAA, 2003, cited in Kruse et al., 2015, p. 580). Therefore, since complete removal of the wellhead platform may be selected for future oil fields in Vietnam, such ecosystem value needs to be further investigated and compared to other options before making the final decision.

6.4. Interplay Between the Socioeconomic Context and Restoration/Decommissioning Outcomes

The local communities’ socioeconomic context was addressed in the form of employment provision during the restoration of Scottish coal sites (Le, 2018). It is not indicated in the field decommissioning plan for X oil field how coastal communities’ socioeconomic context influenced the preparation of decommissioning options. However, the impact of X oil field decommissioning on coastal communities’ socioeconomic development can be predicted.

During the drilling and production phases of X oil field, fishing activities within the 500-m safety zone around the platform were prohibited like many other countries’ legislation (TSJOC, 2007).

Given the complete removal of X oil field after decommissioning (PVEP POC, 2015), the ocean surface and water column will be unobstructed (Kruse et al., 2015). Fishing boats will enjoy an enhancement in accessible area since such prohibition will be lifted. However, due to the small scale of the affected area in compared to the whole fishing ground in the coastal region, there would be no outstanding loss in the coastal communities’ fishery during the drilling and production phases (TSJOC, 2007) and hence no outstanding growth after the project decommissioning. This was probably the reason why coastal communities’ fishery was not indicated as the rationale for selecting the final decommissioning option for X oil field. However, other decommissioning options can help boost coastal communities’ socioeconomic development. For example, partial removal of the platform may strengthen the growth of coastal tourism during a long period if nonconsumptive users or recreational fishing is allowed to access the platform (Kruse et al., 2015). Although marine recreational fishing in Vietnam is underdeveloped (Teh et al., 2014), this can be an attractive tourism service in the future.

In relation to the impacts of decommissioning on the economy of the broader regions or the nation, removing the platform completely will encourage economic development in the short time due to the multiplier effects (Kruse et al., 2015) in terms of, for example, job creation. Decommissioning of oil and gas platforms requires mobilisation of engineers and relevant experts, which thus needs direct investment in local businesses, national universities and centres of expertise to ensure the availability of the proper skills (McCauley, 2018). While this is not mentioned in the decommissioning plan for X field, PVN has been investing in universities and centres of expertise in Vietnam to provide researchers, engineers and skilled workers for the oil and gas industry, including Vietnam Petroleum Institute, PetroVietnam University and PetroVietnam Manpower Training College (PVMTC) (PVMTC, n.d.a; PVU, n.d.; VPI, n.d.). Especially, PVMTC has been the best diving contractor in Vietnam that provides many underwater services, including underwater decommissioning work (PVMTC, n.d.b).

7. CONCLUSIONS

The research analysis shows that there is interplay between contextual factors (biophysical and material conditions, community attributes, biodiversity’s interest, socioeconomic context and rules⁹) and restoration/decommissioning outcomes in Scottish coal sites and X oil field in Vietnam. It also shows that there should be consideration of additional important issues in the preparation of future field decommissioning plans and the update of the related regulations in Vietnam, following the lessons from the closure planning of opencast coal mines in Scotland and researches on decommissioning planning of offshore platforms worldwide.

- While compliance monitoring was a serious problem in East Ayrshire Council to ensure the operator’s compliance with the planning permissions’ requirements, this has not been the issue in X case. Nevertheless, given its occurrence elsewhere, it is better to apply the precautionary approach, that is, compliance monitoring during the life cycle of an offshore

9 The influence of rules is integrated in the analysis of other variables.

oil field should be specified in relevant Vietnam regulations, particularly Decree 95/2015/ND-CP as it currently only requires compliance monitoring for wells (Nghị định 95/2015/ND-CP, Article 77, Item 6)

- Following the studies of decommissioning options for offshore structures around the world, removing or capping shell mounds can be considered for decommissioning of future oil and gas fields in Vietnam. In addition, given the potential impacts of drill cuttings, they should be dredged or covered following a low-risk approach. These can be added to Article 10, Item 2 of Decision 49/2017/QĐ-TTg with a note that potential obstructions from capping shell mounds and covering drill cuttings piles should be consulted with the relevant authority to avoid navigation hazards
- As can be drawn from the lesson of the opencast mining industry in Scotland, a more powerful financial assurance instrument should be applied to Vietnam's oil and gas industry to ensure the financial guarantee fund is sufficiently available for decommissioning throughout the project process, which can be updated to Article 28 of Decision 49/2017/QĐ-TTg. This will help prevent the burden of any remaining decommissioning liability on the Government and potential negative impacts of low-quality decommissioning outcomes on local communities and marine biodiversity
- World Bank Multistakeholder Initiative's (2010) guideline and experience from the restoration of opencast coal mines in East Ayrshire, Scotland point out that local communities' interests should be consulted during the preparation and development of a field decommissioning plan. Given its benefits, consulting local communities' interests should be encouraged if not compulsory in Vietnam's amended regulations on decommissioning of petroleum fields, particularly Article 6, Item 3 of Decision 49/2017/QĐ-TTg
- Due to the outbalance of the reduced biological production possibility over the potential increase in fishable area following complete removal of an offshore platform, rigs-to-reefs options should be considered for future decommissioned platforms in Vietnam. However, since complete removal of offshore structures can also bring ecosystem value, there should be comparison of potential ecosystem value brought from rigs-to-reefs and complete removal options before making the final selection. These require the interest in conserving and enhancing marine biodiversity of the stakeholders involved, which should be encouraged in the relevant laws on decommissioning of offshore oil and gas fields. In addition, issues related to installing a clearly-notified exclusion zone and evaluating potential pollution risks and ultimate liabilities should be clarified in the related laws. Furthermore, navigation hazards should be addressed if rigs-to-reefs is applied to decommissioned structures in Vietnam given the relevant requirements in the national and international laws. All of these issues and rigs-to-reefs approach can be supplemented to Article 23, Item 1 of Decision 49/2017/QĐ-TTg
- Owing to the potential growth of coastal tourism associated with decommissioned structures such as recreational fishing, coastal communities' socioeconomic development should be considered while designing decommissioning options, which can be updated to Article 6, Item 3 of Decision 49/2017/QĐ-

TTg. Although mobilising engineers and relevant experts is not indicated in the decommissioning plan for X field, given the necessity of this human resource for decommissioning Vietnam's oil and gas platforms in the future, there should be continued investment of PVN in research, training and education

With the above-mentioned policy recommendations, this research will contribute to the improvement of decommissioning planning of offshore oil and gas fields in Vietnam. In addition, the conceptual framework developed in this research as adapted from Le's (2018) modified IAD framework can be used for analysing any mines or oil and gas fields in the world. However, one limitation of the study is that it does not analyse the influence of the project context on the stakeholders' interactions during decommissioning planning due to the limited data available. This can be the focus of a future study, whether in the case of X field or other offshore oil fields in Vietnam, in order to investigate: (1) how compliance monitoring was undertaken during the project process, particularly prior to decommissioning; (2) how the stakeholders involved interacted to ensure the financial guarantee fund was sufficient for full decommissioning as required in the field decommissioning plan throughout the project life; (3) how local communities were consulted during the preparation and development of the field decommissioning plan; and (4) how the relevant stakeholders interacted to integrate biodiversity's interest into the field decommissioning plan.

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REFERENCES

- Baillie, J.E.M., Griffiths, J., Turvey, S.T., Loh, J., Collen, B. (2010), *Evolution Lost: Status and Trends of the World's Vertebrates*. London: Zoological Society of London.
- Bernstein, B.B., Bressler, A., Cantle, P., Henrion, M., John, D., Kruse, S., Pondella, D., Scholz, A., Setnicka, T., Swamy, S. (2010), *Evaluating Alternatives for Decommissioning California's Offshore Oil and Gas Platforms: A Technical Analysis to Inform State Policy*. Oakland, California: California Ocean Science Trust.
- Browne, A.L., Stehlik, D., Buckley, A. (2011), Social licences to operate: For better not for worse; for richer not for poorer? The impacts of unplanned mining closure for "fence line" residential communities. *Local Environment*, 16(7), 707-725.

- Burdon, D., Barnard, S., Boyes, S.J., Elliott, M. (2018), Oil and gas infrastructure decommissioning in marine protected areas: system complexity, analysis and challenges. *Marine Pollution Bulletin*, 135, 739-758.
- Cherry, J. (2008), Case study of successful reclamation and sustainable development at Kennecott mining sites. In: Berger, A., editor. *Designing the Reclaimed Landscape*. London, New York: Taylor and Francis Group.
- Convention on the Continental Shelf. (1958), Available from: http://www.legal.un.org/ilc/texts/instruments/english/conventions/8_1_1958_continental_shelf.pdf. [Last accessed on 2019 Mar 16].
- Declaration on the Conduct of Parties in the South China Sea. (2002), Available from: <https://www.cil.nus.edu.sg/wp-content/uploads/2017/07/2002-Declaration-on-the-Conduct-of-Parties-in-the-South-China-Sea.pdf>. [Last accessed on 2019 Mar 15].
- Department of Industry, Innovation and Science. (2018), Offshore Petroleum Decommissioning Guideline. National Offshore Petroleum Titles Administrator.
- DMIRS. (2017), Petroleum Decommissioning Guideline. Department of Mines, Industry Regulation and Safety, Government of Western Australia.
- EAC. (2006), Planning Permission for Application Ref.: 05/0232/FL. Planning Application Ref. 05/0232/FL. East Ayrshire Council.
- EAC. (2010a), Planning Permission for Application Ref. 09/0891/PP. Planning Application Ref. 09/0891/PP. East Ayrshire Council.
- EAC. (2010b), Minute of Agreement among East Ayrshire Council, the Scottish Coal Company Limited, SRG Estates Limited, the Scottish Ministers, and Diana Mary Wheeler. Planning Application Ref. 08/0783/FL. East Ayrshire Council. Available from: <http://www.eplanning.east-ayrshire.gov.uk/online/applicationDetails.do?activeTab=documents&keyVal=K7YN1XGF01S00>. [Last accessed on 2017 Feb 01].
- EAC. (2010c), Minute of Variation of Minutes of Agreement among East Ayrshire Council, Aardvark TMC Limited, The Partners of and Trustees for the Firm of Young Brothers, The Dumfries Estate Trustees and The Scottish Ministers. Planning Application Ref. 09/0891/PP. East Ayrshire Council.
- EAC. (2011a), Minute of Variation among East Ayrshire Council, ATH Resources Plc, Aardvark TMC Limited, and Denise Tait Chambers. Planning Application Ref. 09/0511/PP, East Ayrshire Council. Available from: <http://www.eplanning.east-ayrshire.gov.uk/online/applicationDetails.do?activeTab=documents&keyVal=KMPQAYGF01B00>. [Last accessed on 2017 Feb 01].
- EAC. (2011b), Planning Permission for Application Ref. 09/0511/PP. Planning Application Ref. 09/0511/PP. East Ayrshire Council.
- EAC. (2013), Steps to Recovery Report, East Ayrshire Council. Available from: <http://www.docs.east-ayrshire.gov.uk/crpadmmin/2012%20agendas/council/19%20september%202013/Open%20Cast%20Mining%20Report.pdf>. [Last accessed on 2016 Mar 15].
- EAC. (2014), Application Ref. 13/0865/PP at Duncanziemere Surface Coal Mine, Lugar by OCCW (Duncanziemere) Limited Report by Head of Planning and Economic Development to the Planning Committee. Planning Application Ref. 13/0865/PP. East Ayrshire Council.
- EAC. (2015a), Planning Enforcement Notice for Dunstonhill Site Opencast Coal Mine, near Patna Report by Acting Head of Planning and Economic Development to the Planning Committee. East Ayrshire Council.
- EAC. (2015b), Planning Enforcement Notice for Nethererton Opencast Coal Mine, Skares Report by Acting Head of Planning and Economic Development to the Planning Committee. East Ayrshire Council.
- EAC. (2015c), Update Report Dunstonhill and Nethererton Opencast Coal Sites Revised Restoration Schemes Report by the Chief Governance Officer to the Cabinet. East Ayrshire Council.
- EAC. (2016a), Minutes of Dunstonhill Technical Working Group meeting dated 15 June 2016. Planning Application Ref. 08/0783/FL, East Ayrshire Council. Available from: <http://www.eplanning.east-ayrshire.gov.uk/online/applicationDetails.do?activeTab=documents&keyVal=K7YN1XGF01S00>. [Last accessed on 2016 Jul 21].
- EAC. (2016b), Minutes of Skares Area D public Meeting Dated 29 March 2016. Planning Application Ref. 08/0752/FL. East Ayrshire Council.
- EAC. (2017), Report on Opencast Coal Site Restoration and Aftercare Bonds Report by the Chief Governance Officer to the Cabinet. Confidential Document, East Ayrshire Council.
- Ekins, P., Vanner, R., Firebrace, J. (2005), Decommissioning Scenarios: A Comparative Assessment Using Flow Analysis. Policy Studies Institute. Available from: <http://www.psi.org.uk/docs/2005/ukooa/decommissioning-working%20paper.pdf>. [Last accessed 2018 Mar 29].
- Ekins, P., Vanner, R., Firebrace, J. (2006), Decommissioning of offshore oil and gas facilities: A comparative assessment of different scenarios. *Journal of Environmental Management*, 79, 420-438.
- EUR-Lex. (n.d.), OSPAR Convention. Available from: <https://www.eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM%3A128061>. [Last accessed on 2020 Apr 22].
- Ferreira, D.F., Suslick, S.B. (2000), A new Approach for Accessing Offshore Decommissioning: A Decision Model for Performance Bonds. Stavanger: Paper Prepared for Presentation at the SPE International Conference on Health, Safety, and the Environment in Oil and Gas Exploration and Production, 26-28 June 2000.
- Finger, S., Church, S., von Guerard, P. (2007), Potential for successful ecological remediation, restoration, and monitoring. In: Church, S.E., von Guerard, P., Finger, S.E., editors. *Integrated Investigations of Environmental Effects of Historical Mining in the Animas River Watershed, San Juan County, Colorado*. Chapter F, US Geological Survey.
- Fowler, A.M., Macreadie, P.I., Jones, D.O.B., Booth, D.J. (2014), A multi-criteria decision approach to decommissioning of offshore oil and gas infrastructure. *Ocean and Coastal Management*, 87, 20-29.
- Friends of the Earth Scotland, RSPB Scotland. (2013), Opencast Coal Mining: Liability for Restoration Works. The Royal Society for the Protection of Birds. Available from: https://www.rspb.org.uk/Images/opencast-coal-mining_tcm9-353523.pdf. [Last accessed on 2016 Apr 16].
- Gardner, J.H., Bell, D.T. (2007), Bauxite mining restoration by Alcoa World Alumina Australia in Western Australia: Social, political, historical, and environmental contexts. *Restoration Ecology*, 15, S3-S10.
- Gillespie, M., Glenn, V., Doley, D. (2015), Reconciling waste rock rehabilitation goals and practice for a phosphate mine in a semi-arid environment. *Ecological Engineering*, 85, 1-12.
- Ha, B.T. (2018), Phát Triển Kinh tế Biển Bền Vững: Tiềm Năng, Thách Thức và Định Hướng. Available from: <https://www.thiennhien.net/2018/03/21/phat-trien-kinh-te-bien-ben-vung-tiem-nang-thach-thuc-va-dinh-huong>. [Last accessed on 2019 Mar 17].
- Henrión, M., Bernstein, B., Swamy, S. (2015), A multi-attribute decision analysis for decommissioning offshore oil and gas platforms. *Integrated Environmental Assessment and Management*, 11(4), 594-609.
- ICMM. (2006), Good Practice Guidance for Mining and Biodiversity. London, United Kingdom: International Council on Mining and Metals. Available from: <https://www.icmm.com/page/1182/good-practice-guidance-for-mining-and-biodiversity>. [Last accessed on 2015 Jun 15].
- Jefferies, C. (2018), Exploration Drilling within Block ER236, Offshore of the East Coast of Southern Africa. South Durban Community Environmental Alliance. Available from: <https://www.sdcea.org>.

- co.za/2018/03/27/comments-from-sdcea-on-offshore-oil-and-gas-exploration-drilling-within-block-er2369-of-the-east-coast-of-ken. [Last accessed on 2019 Jun 02].
- Kruse, S.A., Bernstein, B., Scholz, A.J. (2015), Considerations in evaluating potential socioeconomic impacts of offshore platform decommissioning in California. *Integrated Environmental Assessment and Management*, 11(4), 572-583.
- Kuter, N. (2014), Reclamation of degraded landscapes due to opencast mining. In: Özyavuz, M., editor. *Advances in Landscape Architecture*. Ch. 33. London: InTech.
- Lakhal, S.Y., Khan, M.I., Islam, M.R. (2009), An "Olympic" framework for a green decommissioning of an offshore oil platform. *Ocean and Coastal Management*, 52, 113-123.
- Le, H.T. (2018), Exploring the Governance of Post-mining Restoration in Scotland in the Demise of the Opencast Coal Industry and Finding the Way Forward. Scotland: PhD Thesis, University of Dundee.
- Mackinnon, J., Norman, C., Fowle, J. (2014), Report of Independent Review of regulation of opencast coal operations in East Ayrshire. East Ayrshire Council.
- Macreadie, P.I., Fowler, A.M., Booth, D.J. (2011), Rigs-to-reefs: Will the deep sea benefit from artificial habitat? *Frontiers in Ecology and the Environment*, 9(8), 455-461.
- McCauley, D. (2018), Reframing decommissioning as energy infrastructural investment: A comparative analysis of motivational frames in Scotland and Germany. *Energy Research and Social Science*, 41, 32-38.
- Nghị định 95/2015/NĐ-CP. (2015), (Nghị Định quy Định Chi Tiết Một số Điều Của Luật Dầu khí). Available from: <http://www.vbpl.vn/bocongthuong/Pages/vbpq-van-ban-goc.aspx?ItemID=91806>. [Last accessed on 2021 Jan 20].
- Orji, F.M. (2018), Management of Environmental Issues in the Nigerian Oil-producing Region: A Framework for Stakeholders' Collaboration. England: PhD Thesis, University of Central Lancashire.
- Osmundsen, P., Tveterås, R. (2003), Decommissioning of petroleum installations major policy issues. *Energy Policy*, 31(5), 1579-1588.
- OSPAR Commission. (1998), Ministerial Meeting of the OSPAR Commission, Sintra, 22-23 July 1998 Programmes and Measures. Available from: <https://www.ospar.org/documents?v=6877>. [Last accessed on 2020 Apr 22].
- Ostrom, E. (2005), Understanding the diversity of structured human interactions. In: Ostrom, E., editor. *Understanding Institutional Diversity*. Ch. 1. Princeton: Princeton University Press.
- Ostrom, E. (2007), Institutional rational choice: An assessment of the institutional analysis and development framework. In: Sabatier, P.A., editor. *Theories of the Policy Process*. Boulder, Colorado: Westview Press.
- Peck, P., Sinding, K. (2009), Financial assurance and mine closure: Stakeholder expectations and effects on operating decisions. *Resources Policy*, 34, 227-233.
- POC1. (2019), Personal Interview, 14 February 2019. Professional and Owner Certification.
- POC2. (2019a), Informal Conversations with the Corresponding Author, 8 March 2019. Professional and Owner Certification.
- POC2. (2019b), Telephone Conversations with the Corresponding Author, 22 April 2019. Professional and Owner Certification.
- POC2. (2020), Telephone Conversations with the Corresponding Author, 8 May 2020. Professional and Owner Certification.
- Polksi, M.M., Ostrom, E. (1999), An Institutional Framework for Policy Analysis and Design. Workshop in Political Theory and Policy Analysis. Bloomington: Indiana University.
- Pondella, D.J., Zahn, L.A., Love, M.S., Siegel, D., Bernstein, B.B. (2015), Modeling fish production for southern California's petroleum platforms. *Integrated Environmental Assessment and Management*, 11(4), 584-593.
- Powell, J.L. (1988), Revegetation Options. In: Hossner, L.R., editor. *Reclamation of Surface-Mined Lands*. Florida: CRC Press.
- PVEP POC. (2015), Field Abandonment Plan, Confidential Document. Vietnam: PetroVietnam Domestic Exploration Production Operating Company Limited.
- PVEP POC. (2016), Report on Environmental Monitoring Survey before Abandonment of X field, Block Y. Vietnam: Confidential Document, PetroVietnam Domestic Exploration Production Operating Company Limited.
- PVEP POC. (2018), Report on Environmental Monitoring Survey for X Field. Vietnam: Confidential Document, PetroVietnam Domestic Exploration Production Operating Company Limited.
- PVEP. (2015), Biện Pháp Phòng Ngừa và Ứng Phó sự cố Hóa Chất Công Trình mỏ X. Confidential Document. Vietnam: PetroVietnam Exploration Production Corporation.
- PVMTC. (n.d.a.), College Profile, About us, Introduction. PetroVietnam Manpower Training College. Available from: <http://www.pvmtc.com.vn/index.php/en/about-us/introduction>. [Last accessed on 2019 Apr 21].
- PVMTC. (n.d.b.), Introduction, Subsea Services Division. Vietnam: PetroVietnam Manpower Training College. Available from: <http://www.pvmtc.com.vn/ssd/intro.html>. [Last accessed on 2019 Apr 21].
- PVU. (n.d.), About PVU. Vietnam: PetroVietnam University. Available from: <http://www.pvu.edu.vn/en/overview/about-pvu>. [Last accessed on 2019 Apr 21].
- Quyết định 40/2007/QĐ-TTg năm. (2007), (Quyết Định về Việc Thu Dọn Các Công Trình cố Định, Thiết bị và Phương Tiện Phục vụ Hoạt Động Dầu Khí). Available from: http://www.vanban.chinhphu.vn/portal/page/portal/chinhphu/hethongvanban?class_id=1&mode=detail&document_id=21315. [Last accessed on 2019 Feb 16].
- Quyết định 49/2017/QĐ-TTg năm. (2017), (Quyết Định về Việc Thu dọn các Công Trình, Thiết bị và Phương Tiện Phục vụ Hoạt Động Dầu Khí). Available from: <https://www.thuvienphapluat.vn/van-ban/Tai-nguyen-Moi-truong/Quyết-dinh-49-2017-QĐ-TTg-thu-don-cong-trinh-thiet-bi-phuong-tien-phuc-vu-hoat-dong-dau-khi-370298.aspx>. [Last accessed on 2020 Feb 19].
- RSPB Scotland. (2014), Opencast Coal Mining: Moving towards More Effective Regulation. The Royal Society for the Protection of Birds. Available from: https://www.rspb.org.uk/Images/briefing_coal_tcm9-365075.PDF. [Last accessed on 2016 Apr 16].
- Salomons, W. (1995), Environmental impact of metals derived from mining activities: Process, predications, prevention. *Journal of Geochemical Exploration*, 52, 5-23.
- Sassoon, M. (2009), Financial Surety: Guidelines for the Implementation of Financial Surety for Mine Closure. World Bank's Oil, Gas, and Mining Policy Division. Available from: http://www.siteresources.worldbank.org/INTOGMC/Resources/7_eifd_financial_surety.pdf. [Last accessed on 2015 Jun 05].
- Schroeder, D.M., Love, M.S. (2004), Ecological and political issues surrounding decommissioning of offshore oil facilities in the Southern California Bight. *Ocean and Coastal Management*, 47(1, 2), 21-48.
- Snashall, D. (2018), Assessing the Social and Economic Impacts of Oilfield Closure and Decommissioning. Kuala Lumpur: Paper Prepared for Presentation at the SPE Symposium: Decommissioning and Abandonment, 3-4 December 2018.
- Sommer, B., Fowler, A.M., Macreadie, P.I., Palandro, D.A., Aziz, A.C., Booth, D.J. (2019), Decommissioning of offshore oil and gas structures environmental opportunities and challenges. *Science of the Total Environment*, 658, 973-981.
- Techera, E.J., Chandler, J. (2015), Offshore installations, decommissioning

- and artificial reefs: Do current legal frameworks best serve the marine environment? *Marine Policy*, 59, 53-60.
- Teh, L., Zeller, D., Zylich, K., Nguyen, G., Harper, S. (2014), *Reconstructing Vietnam's Marine Fisheries Catch, 1950-2010*, Working Paper No. 2014-17. Canada: The University of British Columbia.
- Tordo, S. (2007), *Fiscal Systems for Hydrocarbons: Design Issues*. World Bank Working Paper No. 123. Washington, DC: The World Bank. Available from: https://www.siteresources.worldbank.org/INTOGMC/Resources/fiscal_systems_for_hydrocarbons.pdf. [Last accessed on 2019 Apr 18].
- Tordoff, G.M., Baker, A.J.M., Willis, A.J. (2000), Current approaches to the revegetation and reclamation of metalliferous mine wastes. *Chemosphere*, 41(1, 2), 219-228.
- TSJOC. (2007), *Environmental Impact Assessment Report for the Z Complex Early Production Project in Block Y Offshore South Vietnam*. Vietnam: Confidential Document, PetroVietnam Domestic Exploration Production Operating Company Limited.
- The Australian Government. (2016), *Mine Rehabilitation*, Department of Industry, Innovation and Science. Available from: <https://www.industry.gov.au/sites/default/files/2019-04/lpsdp-mine-rehabilitation-handbook-english.pdf>. [Last accessed on 2021 Feb 14].
- The National Trust for Scotland and Scottish Natural Heritage. (2008), *Concordat between the National Trust for Scotland and Scottish Natural Heritage 2008*. Scottish Natural Heritage. Available from: <http://www.snh.org.uk/pdfs/concordat.pdf>. [Last accessed on 2018 May 26].
- The Sunday Herald. (2013), *Councils Left with £200m Shortfall in Funds to Clean up Opencast Mines*. The Sunday Herald (Online Edition), 8 December. Available from: http://www.heraldsotland.com/news/13135416.Councils_left_with_200m_shortfall_in_funds_to_clean_up_opencast_mines. [Last accessed on 2017 Mar 11].
- Trung tâm Nghiên Cứu và Phát triển an Toàn và Môi Trường dầu khí. (2017), *Chương Trình Quản lý an Toàn Dự án Vận Hành mỏ X*. Vietnam: PetroVietnam Domestic Exploration Production Operating Company Limited, Confidential Document.
- United Nations Convention on the Law of the Sea. (1982), Available from: http://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf. [Last accessed on 2019 Mar 16].
- United Nations Treaty Collection. (n.d.), *Convention on the Continental Shelf*. United Nations Treaty Collection. Available from: <https://www.treaties.un.org/doc/Publication/MTDSG/Volume%20II/Chapter%20XXI/XXI-4.en.pdf>. [Last accessed on 2019 Mar 16].
- Viet Nam News. (2019), *PVN Sets Target of Adding up to 30m Tonnes to Oil Reserves*. Viet Nam News (Online Edition), 15 March. Available from: <https://www.vietnamnews.vn/economy/507134/pvn-sets-target-of-adding-up-to-30m-tonnes-to-oil-reserves.html>. [Last accessed on 2019 May 24].
- VPI. (n.d.), Ngày 22-5-1978, *Lịch sử Hình Thành và Phát Triển*. Vietnam: Vietnam Petroleum Institute. Available from: <https://www.vpi.pvn.vn/lich-su-hinh-thanh-va-phat-trien>. [Last accessed on 2019 Apr 21].
- Wood, A., Stedman-Edwards, P., Mang, J., editors. (2000), *The Root Causes of Biodiversity Loss*. London: Earthscan Publications.
- World Bank, International Finance Corporation. (2002), *It's Not Over When It's Over: Mine Closure Around the World*. Washington, DC: The World Bank. <http://siteresources.worldbank.org/INTOGMC/Resources/notoverwhenover.pdf>. [Last accessed on 2018 Aug 31].
- World Bank, Multistakeholder Initiative. (2010), *Towards Sustainable Decommissioning and Closure of Oil Fields and Mines: A Toolkit to Assist Government Agencies*. Washington, DC: The World Bank Group.
- Yin, R.K. (2014), *Case Study Research: Design and Methods*. London: Sage Publication.

APPENDIX

Appendix 1: Literal and theoretical replication between Scottish coal mines and X oil field

Variables	Dunstonhill, Duncanziemere and Netherton	X oil field
Biophysical and material conditions		
Post-mining/post-production biophysical environment	A constraint on mine restoration	Not a constraint on decommissioning
Financial assurance	Insufficient for mine restoration	Sufficient for decommissioning
Community attributes		
Local communities' interests	Consulted for the revised restoration plans	Not consulted for the decommissioning plan
Biodiversity's interest	Integrated in the revised restoration plans	Not integrated in the decommissioning plan
Socioeconomic context	Considered in the revised restoration plans	Not considered in the decommissioning plan
Rules		
Operational, collective-choice and constitutional levels	Influenced mine restoration	Will influence decommissioning

Source: The authors